

AN EVALUATION OF THE USE OF PORTABLE GENERATORS AND CARBON  
MONOXIDE POISONINGS AND DEATHS FOLLOWING HURRICANES IN  
FLORIDA

Leading Community Risk Reduction

BY: Gregory D. Giaccone  
Delray Beach Fire-Rescue  
Delray Beach, Florida

An applied research project submitted to the National Fire Academy as part of the  
Executive Fire Officer Program.

February 2008

### Abstract

The purpose of this research is to identify successful methods that can be utilized to decrease carbon monoxide exposures and deaths. The problem is that residents are experiencing a significant increase in carbon monoxide poisonings and deaths due to generator uses following hurricanes.

The research was conducted utilizing descriptive research methods to answer the following research questions; How widespread is the problem? What laws and ordinances are currently in place to address this issue? What public education programs are currently in place to address the problem? What can generator manufacturers do to assist with addressing the problem?

The research was conducted utilizing books, journals, personal interviews, department documents, a survey, and the internet to gather information on generators and carbon monoxide poisoning. Some of the findings from the research included the current impact of the problem, current legislative efforts to address the problem, public education programs targeting the problem, and product improvements to reduce the problem.

The recommendations from the research indicated that the department must do a better job of communicating the hazards to citizens, coordinating public education efforts with other agencies, enforcing current and future legislation that addresses the problem, and advocating improvements to the product to manufacturers.

## Table of Contents

Abstract.....	2
Table of Contents.....	3
Introduction.....	4
Background and Significance.....	5
Literature Review.....	7
Procedures.....	15
Results.....	18
Discussion.....	20
Recommendations.....	25
Reference List.....	28
Appendix A.....	32
Appendix B.....	35
Appendix C.....	38

## Introduction

In August and September of 2004 the state of Florida was struck by four major hurricanes named Frances, Jean Wilma, and Charley. All four of these storms struck heavily populated portions of Florida leaving major power outages in their wake. These power outages ranged from a low of 874,000 without power after hurricane Charley to a record high of 3.2 million after hurricane Wilma.(FPL, 2007) For comparison purposes, hurricane Andrew which struck in 1992 only left 1.4 million without power. Due to the extensive damage to transmission and distribution lines, many customers were forced to wait in excess of two weeks for power to be restored to their residences and businesses. As a result many resorted to the use of portable generators to supply power to their place of residence and businesses. It is estimated that between 18 and 54 percent of households in Florida used a generator after one of the hurricanes in 2004. (Van Sickle, 2007) As a result of this generator usage, Floridians experienced record numbers of carbon monoxide poisonings and fatalities in the weeks following the hurricanes. The City of Delray Beach experienced residents that were significantly exposed, as well as succumbed to carbon monoxide exposure.

The problem is that residents are experiencing a significant increase in carbon monoxide poisonings and deaths due to portable generator usage subsequent to hurricanes. The purpose of this applied research project is to identify successful methods that can be utilized to decrease carbon monoxide exposures and deaths.

The author of this applied research paper will utilize descriptive research and the following four questions to guide the researchers' efforts: How widespread is the problem? What laws and ordinances are currently in place to address this issue? What

public education programs are currently in place to address the problem? What can generator manufacturers do to assist with addressing the problem?

### Background and Significance

The Delray Beach Fire Department is located in Southern part of Palm Beach County in Southeast Florida. The area served by the department includes the City of Delray Beach and the Towns of Gulf Stream and Highland Beach. All three communities are situated along the coast on the Atlantic Ocean. The combined population served by the department is approximately 75,000 and covers 17 square miles. The department has a total complement of 151 personnel including 143 certified firefighters. (DBFD annual report, 2007) From its six stations, The Delray Beach Fire Department provides fire suppression, advanced life support emergency medical services, prevention, inspection, hazardous materials response, and a multitude of other community oriented programs. The daily shift staffing is 33 emergency response personnel. The department is currently responding to more than 12,000 emergency requests for service annually.

The problem of carbon monoxide poisoning from portable generators is one that is rapidly rising since the 2004 and 2005 hurricane season. Prior to that, the use of portable generators by citizens was not very common. The last major storm to strike South Florida was hurricane Andrew in 1992 which primarily affected the Southern part of Dade County which is not densely or heavily populated. As a result, the power company was able to restore power rather quickly to a majority of its customers. The hurricanes of 2004 and 2005 struck major metropolitan areas along the Southeast coast including Delray Beach which are heavily populated. As a result the number of people without power was extremely high. This clearly exceeded the capabilities of the primary

power company, FPL to respond in a timely manner. As a result people resorted to using portable generators to meet their power needs. In recent years the price of a portable generator has fallen to a price point that is affordable to the average homeowner.

Availability of these units has also increased with numerous models available at big box home stores, supermarkets, drug stores and even gas stations. Immediately after the passing of storms out of state rental trucks set up shop on various corners of major intersections selling generators. In the weeks following the storm the department responded to numerous situations where portable generator were being utilized inside residences, businesses, and even inside enclosed stairwells of hi-rise condominiums.

Portable generators are no longer viewed as a luxury but a necessity. The future impact of the problem is likely to increase as forecasters are calling for increasing frequency and strength of storms in the future.

The problem that exists in the City of Delray Beach has many significant connections to the Leading Community Risk Reduction course in the Executive Fire Officer Series. After completion of a community risk assessment, hurricanes are a high risk event affecting the city and are becoming higher in frequency. Carbon monoxide poisoning from portable generators is preventable. With proper intervention strategies, all stakeholders can benefit from increased awareness, education, and engineering practices to reduce the problem. Because there is existing data to support the problem we can evaluate the effectiveness of any measures instituted to reduce the frequency.

The problem is related to two of the USFA operational objectives which include; 2,500 communities will have a comprehensive multi-hazard risk reduction plan led by or including the local fire service, and to appropriately respond in a timely manner to

emergent issues. Because this problem is an emergent issue it should be included as a component of the city's comprehensive emergency response plan.

### Literature Review

How widespread is the problem? The Center for Disease Control completed a study of emergency room patients during the 2004 hurricane season in an attempt to evaluate the problem. The study focused on only 10 hospitals that were located within fifty miles of the center of the hurricane as it passed through the state. All information was gathered from August 13, 2004 through September 28, 2004. The study confirmed 167 poisonings and six fatalities from carbon monoxide. (CDC, 2005) In 1999 generators were the cause of only 6 percent of carbon monoxide related deaths. (NFPA, 2007) Today, generators are the second leading cause of carbon monoxide poisonings comprising of 24 percent of cases and that number is rising. This is second only to fuel burning heating systems. (CPSC, 2006) A NFPA study of annual fire incident reporting also shows a steady rise in non fire carbon monoxide incidents from 2003 to 2005. In 2003 there were 51,700 reported cases and in 2005 there were 61,100 cases. (Flynn, 2007)

According to CPSC, the average size portable generator sold to consumers is between 5 and 6.5 kw. This size generator is typically powered by a simple gasoline combustion engine of the same type found in lawn equipment. This type of engine is chosen because it is relatively simple and cheap to produce. This engine is also very inefficient because it lacks modern controls such as electronic fuel injection and catalytic converters similar to what is found on modern passenger vehicles. This inefficiency greatly increases the production of emissions particularly carbon monoxide. "A 10

horsepower generator produces carbon monoxide emissions at a rate 450 times that of modern idling cars.”(Frey, 2003)

There are numerous reasons for the widespread use of portable generators after hurricanes. The primary reason in Florida is the weather where the hurricane season stretches from June to November. These months typically are very hot and humid requiring air conditioning for living spaces. Weather following a hurricane is typically very still and humid as a result of the rainfall associated with the storm. The older adults and the very young are very susceptible to heat related emergencies during the summer months and thus rely on portable generators to keep them cool. According to the 2000 census, 28.7 percent of the population is over the age of 62. (Delray Beach, 2000)

Another reason for the use of portable generators after a hurricane is the need for refrigeration and cooking of food. Prior to landfall in preparation for a storm residents typically stock up on food and water knowing that they may be without power for a period of time following the storm. In order to keep the food and drinks fresh they must use a generator to run the refrigerator. Additionally, many of the older adult residents have medications and supplies that must be temperature controlled which also required refrigeration.

The reason for the increased numbers is their ever increasing presence in the homeowner market. Prior to 1999 it was not very common for the average homeowner to own a portable generator. The price was simply too high and its use was primarily relegated to the contractor market. The reason sales began to increase in 1999 was due to Y2K fears. (CPSC, 2006) This increase in demand was met by increased production and ultimately reduced the price to a point where it became affordable to the average



homeowner. Today they are available at all major retailers like Home Depot, Lowe's, Wal-Mart, and Target. Sixty percent of generator sales to consumers are priced between 300 and 800 dollars. (CPSC, 2006) Their popularity has risen so much that cheap Chinese imported models are now available at supermarkets and drug stores and even gas stations. The market now has models at price points that are available to everyone and the generator manufacturers have had record sales. "Some companies are reporting 2005 sales figures totaling more than the previous four years combined." (Consumer Reports, 2006)

What laws and ordinances are currently in place to deal with the problem? NFPA 110, the standard for emergency and stand by power systems does give guidance on the use and installation of back up power systems; however, it only applies to fixed systems. With regards to carbon monoxide, the standard requires that the exhaust outlet be a minimum of five feet from any window or opening and be directed away from such opening. Portable generators are not subject to this requirement.

Underwriters Laboratories along with the CPSC is responding to the increase in carbon monoxide poisonings by directing staff to review portable generator safety. As a result they developed requirements to address the following four issues; "consumer exposure to unsafe CO emissions, safe outdoor use of generators in rain or other poor weather conditions to reduce the potential risk of shock or electrocution, cautionary marking for the product, packaging and instructions to adequately warn consumers of the CO and electrocution hazards and inform them of the appropriate safety measures." (CPSC, 2007) As a result the CPSC adopted a requirement that all generators include warning labels to alert consumers to the CO hazard. This requirement is voluntary

however; UL has made the labeling a requirement for a generators to receive the UL listing.

On July 1 2007 the Governor of Florida signed into law Florida Statue 553.585 regarding carbon monoxide detectors. The statue requires that every building for which a permit is issued that has a fossil fuel burning heater, appliance, fireplace, or an attached garage to have a carbon monoxide detector installed within ten feet of any sleeping room after July 1, 2008.

The city of Delray Beach has adopted an ordinance regarding portable generators as a result of experiences from the 2004 hurricane season. (Appendix C) The ordinance is an adaptation from the NFPA 110 requirement for permanently installed back up generators. The sole intention of the adoption of this ordinance is to address the unsafe use of a generator that leads to CO poisoning.

What public education programs are currently in place to deal with the problem? Following the hurricane seasons of 2004 numerous federal, state, and local agencies along with public utility operators made attempts to publicize the dangers of carbon monoxide poisoning associated with portable generators. In most cases these announcements attempted to educate the public on the signs and symptoms of carbon monoxide exposure along with the proper use of a portable generator. At the federal level FEMA began to address the issues associated with generators in September of 2004 with a press release stating, “while portable generators are useful when temporary or remote electric power is needed, generators also can be extremely hazardous and even life-threatening.”(FEMA, 2004) They further outline the primary hazard of generators is carbon monoxide poisoning stating,” The primary hazards when using a generator are

carbon monoxide poisoning from the toxic engine exhaust, electric shock or electrocution, and fire. Most of the deaths and injuries associated with portable generators are from CO poisoning from generators used indoors or in partially enclosed spaces.”(FEMA, 2004) FEMA recognized the need for portable generators so much that they reimbursed residents for purchasing portable generators following the 2004 hurricane season. The United States Fire Administration also has addressed the issue of carbon monoxide poisoning from generators on its website. It states that annually 480 lives are lost and 15, 200 people are treated in emergency rooms for carbon monoxide poisoning. (USFA, 2007) On the USFA website there are links to public service announcements and videos regarding portable generator safety.

At the state level many state agencies are also involved in public education programs with press releases delivered at the beginning of hurricane season and during each storm. The Florida Department of Health delivered a release focusing on carbon monoxide poisoning from generators that stated, “always locate the unit outdoors on a dry surface, away from doors, windows, and vents, and air conditioning that could allow CO to come indoors.”(FDOH, 2006) The release also advises residents to install a battery operated carbon monoxide detector or a plug in detector with battery back up in all homes that will use a generator after a hurricane. The Florida Division of Emergency Management prepared a press release at the beginning of the 2007 hurricane season promoting the states sales tax holiday for hurricane supplies. The release encouraged residents to purchase hurricane related supplies and exempted generators under \$1000.00 and carbon monoxide detectors under \$75.00 from state sales tax during the holiday. (FLDEM, 2007)

There are also public education programs aimed at the use of generators and carbon monoxide poisoning at the local level. The researcher was able to locate numerous press releases from city and county agencies that are a redistribution of the same information the state is distributing. In most cases this was disseminated from either the local fire department or the emergency operations center. At the local level the local electric company distributed numerous public safety announcements regarding portable generators however; they focused on illegal back feeding into the grid and not carbon monoxide poisonings.

The city of Delray Beach Fire Department took a unique approach to the problem under the direction of LT. Trisha Dunkelman. When asked how she decided to approach the program she stated, “I wanted to draw extensive media attention to the problem and the annual hurricane preparedness sales tax holiday always seemed to get media coverage. I decided that I would try to use that to get out the message.”(Personal communications LT Trisha Dunkelman Delray Beach Fire Rescue, November 12, 2007) Lt. Dunkelman was able to get Home Depot to commit to give away a free carbon monoxide detector to every customer who bought a generator during the exemption period. Additionally the fire department also provided safety literature to alert buyers to the dangers of carbon monoxide poisoning. This generated extensive media coverage with numerous interviews which provided opportunities for public education.

What can generator manufacturers do to assist with addressing the problem? The CPSC has evaluated the carbon monoxide problem with portable generators and has moved toward requiring manufacturers to label them to alert users to the dangers of carbon monoxide. The label they are proposing, “ includes pictograms and statements

warning consumers that a generator's exhaust contains poisonous carbon monoxide and that a generator should NEVER be used inside the home or in partially enclosed areas such as garages.”(CPSC, 2006) The CPSC was successful in passing a law that goes into affect on May 14, 2007 that requires signage on the generator with strong wording that states,” Using a generator indoors can KILL YOU WITHIN MINUTES.”(CPSC, 2007)

Generator manufacturers in the marine industry have developed carbon monoxide detectors that interface with generators. The marine industry did this in response to increasing instances of carbon monoxide poisonings aboard houseboats. Fireboy/Xintex has developed a CMD-4MR-RLY detector that features automatic generator shutdown capability. The unit is designed to work on 12 volt operation which is consistent with most electric start consumer model generators. “When dangerous CO levels are detected, the CMD-4MR-RLY shuts down the generator, a common source of CO.”(Fireboy, 2007) The unit is UL 2034 listed which is the standard for carbon monoxide detectors. The researcher located this model available on line at numerous locations for as little as \$119.00.

The researcher located information regarding the use of emission control equipment on small engines such as those that power generators. Technology has developed to the point that this equipment is now at a price point that it’s a viable option to reduce emissions from small engines. The addition of fuel injection to small engines can dramatically reduce carbon monoxide emissions from small engines. Delphi Automotive has developed an electronic fuel injection system that has this capability. “It assists in reducing exhaust emissions to help meet regulatory standards and reduced carbon monoxide emissions for better product safety versus conventionally carbureted

systems.”(Delphi, 2006) Additionally the company gained a 15 percent improvement in fuel economy with the engine.

Catalytic converters are an option for generator manufacturers to use to help reduce carbon monoxide emissions from small engines. The converter passes exhaust gasses over a catalyst that changes emissions to water vapor. In the case of carbon monoxide it is changed to carbon dioxide. (Nice, 2006) The addition of a catalytic converter alone reduces carbon monoxide output by fifty percent. The number is even greater when combined with a fuel injection system. (Technology, 2007) Small engine manufacturers are beginning to incorporate this technology into their products in response to requirements set forth by CARB or the California Air Resource Board. CARB requirements are aimed at reducing air pollution in California however; they are forcing engine manufacturers to develop new ways reduce overall emissions generated by combustion engines.

The use of alternative fuels can assist in reducing carbon monoxide emission from small engines. The current item that is limiting its use in small engines is the type of fuel lines installed in them. They are not compatible with the alcohols in today’s blended fuels. (Lawn and Landscape, 2006) A simple change out of the fuel lines and seals will enable a small engine to operate using these blends. Testing by the Renewable Fuels Association revealed that carbon monoxide tailpipe emissions were reduced by over 30 percent. They further state, “the use of ethanol blended fuel is one of the best pollution control strategies for off road power equipment represents a significant source of emissions.” (RFA, 2007)

Propane is also a viable option to power portable generators with a significantly reduced carbon monoxide emission level. According to the Propane Council, carbon monoxide emissions from small standby generators were 90 percent lower than that of gasoline powered models. (Propane Council, 2006) The researcher was able to locate numerous kits to convert existing small engines to propane power in the \$100.00 to \$300.00 range. Additionally manufacturers such as Generac, Briggs and Stratton, and Honda all offer their own factory kits at a similar price.

The findings in this literature review influenced the project by providing foundation for how it would proceed. It clearly identified the seriousness of the problem as well as increased future exposure. It also exposed a variety of approaches to improving the problem. This information was compiled to formulate the survey which was distributed and evaluated to formulate recommendations.

### Procedures

This researcher will utilize descriptive research on several different sources to develop the research base in order to provide answers to the research questions. The researcher began the search for source material on carbon monoxide poisonings from the use of portable generators after a hurricane at the National Fire Academy Learning Resource Center. While there was extensive material available on the subject, much of it was in relation to carbon monoxide poisonings after ice storms in the United States. The internet research yielded significant information on the specific subject of the use of portable generators after a hurricane and carbon monoxide poisonings. The researcher did utilize much of this material from government agencies which is cited extensively in

the literature review section. Additionally DBFD documents were also utilized for reference.

The researcher also conducted numerous personal interviews with Lt. Trisha Dunkelmann throughout the research process. Lt. Dunkelmann was chosen because she is the current Community Education Specialist within the department. In addition to the personal interviews, Lt. Dunkelmann was able to provide the researcher with data on the generator and carbon monoxide detector program from its inception as well as research she conducted prior to her appointment to the position. All communications with Lt. Dunkelmann took place between November 12, 2007 and November 28, 2007. Lt. Dunkelmann was asked the following questions:

- 1) Can you tell me a little bit about your role and responsibilities as the department Community Education Specialist?
- 2) How did you identify the problem of carbon monoxide poisonings from the use of portable generators?
- 3) What community education methods are being implemented to deal with the problem?
- 4) How successful are the community education programs that have been implemented in addressing the problem?

In order to gain further data to answer the researchers' questions, a survey was prepared. The survey was developed utilizing the research questions as a guide. Additionally, the questions were formulated based on research completed. Two survey questions were prepared for each research question. The survey was reviewed by Lt.



Dunkelmann for review prior to administration. All questions were forced choice questions in a multiple choice format.

The survey was distributed to the Palm Beach County Training Officers Association on December 5, 2007. It was delivered via the email list of members kept by the organizations president. At the time of distribution the list contained 52 persons with representatives from every city, county and private provider of fire and rescue services in Palm Beach County. Of the 52 persons to whom the survey was distributed to 21 were returned. The 21 that were returned represented all but three very small organizations located within the county. The returned surveys were representative of 15 of the 18 fire rescue departments in Palm Beach County.

The following is a list of limitations and assumptions that may have had an affect on this applied research project: The comparatively small amount of research available explicit to carbon monoxide poisoning, and the use of generators after a hurricane. Time constraints placed on the researcher due to other collateral responsibilities.

The following is a list of definitions and terms utilized by the researcher in this document:

CDC Centers for Disease Control

CO carbon monoxide

CPSC Consumer Product Safety Commission.

DBFD Delray Beach Fire Department

FDOH Florida Department of Health

FEMA Federal Emergency Management Agency

FLDEM Florida Division of Emergency Management

FPL Florida Power and Light

NFPA National Fire Protection Association

UL Underwriters Laboratories

USFA United States Fire Administration

## Results

### Research Question #1

How widespread is the problem? According to the research, the problem appears to be very widespread. A clear majority of the respondents were aware of a carbon monoxide poisoning incident related to portable generator use within their own jurisdiction or one within Palm Beach County. This is consistent with the research conducted which shows a dramatic increase in non fire related CO poisonings. Questions 1 and 2 in the generator survey (Appendix A) are targeted at this question. Question 1 asks: Are you aware of any carbon monoxide poisonings or deaths due to the use of a portable generator after a hurricane within your jurisdiction? 12 respondents answered yes while 9 answered no. Question 2 asks: Are you aware of any carbon monoxide poisonings or deaths due to the use of a portable generator after a hurricane within Palm Beach County? 19 respondents replied yes and 2 replied no. The findings of the survey are consistent with the research in that there is little legislation that is aimed specifically at reducing CO poisoning from portable generators.

### Research Question #2

What laws and ordinances are currently in place to address this issue? The initial research into the problem revealed that legislation could be effective in reducing the problem. Existing legislation was found that directly targeted the use of the generators

themselves as well as installation of CO detection and alerting equipment installed in buildings. These survey questions were targeted at determining what the current legislation was targeting. Questions 5 and 6 from the generator survey (Appendix A) address research question #2. Question 5 asks: Has your local jurisdiction enacted any rules to address the use of portable generators? 3 respondents answered yes and 18 answered no. Question 6 asks: Does your jurisdiction require carbon monoxide detectors in new construction? 1 answered yes and 20 answered no.

#### Research question # 3

What public education programs are currently in place to address the problem? These questions were posed to determine what other organizations are doing or willing to do to address the problem. Questions 3 and 4 in the generator survey (Appendix A) are targeted at research question 3. Question 3 asks: What was done by your agency to address the problem of carbon monoxide poisoning from portable generators 5 answered public service announcements, 1 answered increased patrols, 2 answered reverse 911 messaging, and 14 answered nothing. Question 4 asks: Would your organization consider adding a carbon monoxide detector component to you existing smoke alarm program? 20 answered yes, and 1 answered no. The answers from question 3 of the survey do not correlate with the research in that there were numerous PSA's from numerous organizations located. This may be a result of a poor method selected for distribution.

#### Research question #4

What can generator manufacturers do to assist with addressing the problem? The research revealed that there were many different ways generator manufacturers could assist in reducing the problem. The survey questions were posed to determine both

support for requiring manufacturers to install equipment and what kind of equipment to reduce CO poisonings and deaths. Questions 7 and 8 of the generator survey (Appendix A) were targeted at research question #4. Question 7 asked: Would you support requiring generator manufacturers to add equipment to make them safer in respect to carbon monoxide poisonings? 21 answered yes, and 1 answered no. This revealed that there was significant interest requiring manufacturers to install the necessary equipment to reduce the problem. Question 8 asked: Which of the following is the most important improvement a generator manufacturer should implement to lower incidents of carbon monoxide poisonings and deaths? 4 answered reduce carbon monoxide emissions, 1 answered improve signage, 16 answered detection equipment that shuts the unit down when elevated carbon monoxide levels are detected. The survey results are consistent with the solution chosen by the marine industry to address the issue of CO poisoning in the research.

### Discussion

When determining how widespread the problem is I look at the research performed by the CDC evaluating the emergency room patients immediately following the hurricanes of 2004. (CDC, 2005) The fact that the study only evaluated patients from 10 hospitals and revealed 167 incidents of CO poisoning in a six week period is telling. These 10 hospitals are only a fraction of the hospitals that exist within the path of the storms. Palm Beach County alone has 12 hospitals and only 2 were included in this study. I can only deduce that that actual numbers of incidents were significantly higher as the storms impacted other major urban areas. I also believe the information from the CPSC shows that carbon monoxide poisonings from the use of generators is significant.

Generators were responsible for 6% of carbon monoxide poisonings in 1999 and have grown to the second leading cause of CO poisonings in 2006. (CPSC, 2006) The results of the generator Survey (Appendix B) support the fact that the problem is widespread and growing. More than half were aware of a CO poisoning or death within their jurisdiction and almost all respondents were aware of one within the county. With generator prices continuing to drop, they are becoming more affordable and thus more prevalent in the community. Manufacturers are responding to the demand and are having record sales with some stating 2005 sales were higher than the previous four years combined. (Consumer Reports, 2006) Much of this is spurred by the extensive media coverage of the hurricane season of 2004 and 2005 and the public's response to being prepared. All of the research indicates that the problem is widespread and is still spreading.

With regards to what laws or ordinances were in place to address the issue there was little in place to deal specifically with portable generators and carbon monoxide poisonings. However, many government agencies are in the process of reviewing options due to the rapid increase in incidents. The CPSC and UL are at the forefront of developing rules but to date have only come up with a requirement that manufacturers post a warning label on the machine to warn users of the potential CO hazards. (CPSC, 2007) Of concern is that they also require a label to warn users to operate the machine in a dry area which some feel prompts people to operate them in an enclosed area, such as a garage, for fear of electrocution.

The installation of a carbon monoxide detector in a residence will alert occupants to the presence of CO within the structure. Although not directly focused on portable generators, a law requiring such would have a positive impact on the problem. A law that

was passed by the Florida legislature, Florida Statue 553.585, requires a CO detector installation in every building for which a permit is issued that has a fossil fuel burning heater, appliance, fireplace, or attached garage to install CO detectors within 10 feet of each sleeping room. This goes into effect on July 1, 2008 and will also have a positive impact on the problem. Although it does not apply to every building, it would apply to a vast majority.

The survey results revealed that little was being done at the local level to address the issue from a legislative perspective. Only three respondents said that their jurisdiction had enacted any rules to address the use of portable generators. (Appendix B) An online search of those entity's municipal and county codes revealed that all of the legislation was directed at allowing an exemption to noise ordinances for generators after natural disasters. The only legislation directed at reducing CO poisonings is one from the City of Delray Beach. (Appendix C) Additionally, only one respondent indicated that their jurisdiction required carbon monoxide detectors in new construction. (Appendix B) My interpretation of the results from the survey as well as the literature review is that we can do a much better job in enacting legislation to deal with the problem at the state and local level.

The literature review revealed that there is an effort at all levels federal, state, and local to implement various public education programs to deal with the CO threat from portable generators. Research revealed numerous press releases from almost every federal agency including FEMA, CDC, CPSC and even the USFA. Similar press releases were revealed at the state level from numerous state agencies including SERT, FDOH, and FLDEM. The survey research did not indicate there was a significant public

education effort as 14 of the respondents indicated their agency did not engage in any public education programs regarding the issue. (Appendix B) Of those that did engage in such activities, the greatest participation came in the form of public service announcements using the media which consisted of 5 respondents. Two respondents advised their agency utilized reverse 911 messaging and only one indicated they actively patrolled. The respondents did, however, indicate they would overwhelmingly support adding a carbon monoxide component to their existing smoke detector program. All but one indicated they would welcome this.

In many cases the press releases gave conflicting information to users such as one from the Florida Department of Health which stated, “always locate the unit outdoors on a dry surface, away from doors, windows, and vents, and air conditioning that could allow CO to come indoors.”(FDOH, 2006) The reference to locating the generator on a dry surface could again cause some to locate the unit under a patio or within a garage to keep it dry. The local news media also plays a significant role in helping educating the public as well. Following hurricanes there are extensive public service announcements regarding the use of generators from local public officials. The media also extensively covered CO related fatalities as well which provided opportunities for public officials to get out the message about generator safety. The media also extensively covered the large amounts of generator thefts. This proved to be important because the number one reason affecting the placement of a portable generator was the risk of theft. (CDC, 2006)

There were other creative public education programs that did seem effective such as the free CO detector give away with a generator purchase at Home Depot. According to Lt. Trisha Dunkelman, the local Home Depot experienced a “60% increase in

generator sales as a result of the give away program.” She indicated that they have contacted her regarding expansion to other surrounding stores for the next sales tax holiday for hurricane supplies. Another creative program was to capitalize on the states sales tax holiday to promote the purchase of a CO detector tax free. (FLDEM, 2007) This also provides additional opportunities to get the message out about CO and portable generators. The data compiled in the area of public education indicates to me that there are several ways to implement a good public education program in regards to CO poisoning from portable generators; however, they seem to be fragmented with slightly different and sometimes confusing message. A more coordinated approach would be more effective and successful.

The research regarding what generator manufacturers can do to assist with addressing the problem in the findings of the literature review and the survey results agrees. 20 out of 21 respondents indicated they would support requiring manufacturers to add equipment to make generators safer with respect to carbon monoxide poisonings. (Appendix B) The review revealed that there are numerous ways to approach the problem. At a very cost effective level additional signage with strong wording stating, “using a generator indoors can kill you within minutes.” was implemented by the CPSC. (CPSC, 2007) According to the survey, only one respondent indicated this would be one of the most important improvements a generator manufacturer could make. (Appendix B)

The literature review revealed numerous improvements that could be made to the engine to reduce CO emissions such as electronic fuel injection which reduces CO emissions. (Delphi, 2006) Additionally, a catalytic converter could be fitted to the engine to further reduce CO emissions by fifty percent. (Technology, 2007) The literature



review also exposed the ability to utilize alternative fuels as another way to reduce CO output of the engine. Ethanol blends can reduce CO output by up to 30%. (RFA, 2007) Propane provides an even lower level by reducing CO output by 90% over gasoline powered engines. (Propane Council, 2006) The survey results revealed that 4 out of the 21 respondents favored using these methods to deal with the problem.

A unit that is currently being used in the marine industry in response to CO poisonings is a CO detection system that integrates with the engine switch to shut it off. “When dangerous CO levels are detected, the CMD-4MR-RLY shuts down the generator, a common source of CO.” (Fireboy, 2007) I personally feel that this provides the highest level of safety for the user. The survey agrees with this assessment as 16 of the 21 respondents feel that this is the most important improvement a generator manufacturer can make to reduce CO poisonings and deaths. This improvement could be easily adapted to work on portable generators at minimal cost to the manufacturers.

The organizational implications of the study will help to improve our effectiveness in reducing incidences of carbon monoxide poisonings from portable generators. From the study, recommendations will be made to improve the current education, enforcement, and engineering methods to deal with the problem.

### Recommendations

Based on a thorough review of information gathered in this study, the following recommendations are made. The department must do a better job in exposing the dangers of CO poisoning associated with portable generators. Although we have been proactive in the areas of public education and developing legislation we must continue to work to improve. We must seek opportunities that continue to highlight the problem because if

we have even a short period of inactive hurricane seasons, the message will be forgotten. Opportunities do exist for partnering with other organizations to synergize our efforts and they should be implemented. This should include authorities at the state and local level to create a common message and campaign without confusion to the public. Plans must be made to increase exposure during hurricane season and just prior to the arrival of a storm. A well coordinated campaign will have the desired effect of decreasing the problem.

An enforcement plan should also be developed that can be implemented immediately after a storm has passed. Internally, our hurricane plan should be changed to utilize fire inspectors post storm to conduct inspections of condominiums, high rises, and large multifamily units to check for portable generators being used in an unsafe manner. Outside the department police and city workers should be educated on the city ordinance regarding the use of portable generators and advised to look out for unsafe operations during their duties or patrols. The intention of this activity should be from an educational standpoint; however, enforcement should be initiated if required. Enforcement activities may avert a potential poisoning or fatality, but the more important result is showing that we care and are serious about preventing a potential problem.

Recommendations to the generator manufacturers include adding equipment and systems to reduce CO output from their engines as well as adding safety equipment similar to the CO detector and engine cut off system. For an industry that experienced growth in one year equal to the previous four years, it is not unreasonable to expect that some of those profits are reinvested in engineering additional safety into the product.

In closing, the results of this study clearly show that CO poisoning from portable generators is a growing and significant problem, and there is significant interest in preventing further tragedies. The researcher would recommend to future readers of this paper that the potential for problems with CO poisoning from portable generators is growing annually. The lack of an active hurricane season for even one year will cause the focus to shift from this subject. Constant efforts must be made to educate the public about the dangers of improperly using a portable generator. Just prior to the arrival of a hurricane is too late.

## References

(2007). History of hurricanes. Retrieved January 16, 2008, from FPL.com Web site:

[http://www.fpl.com/storm/hurricane\\_history.shtml](http://www.fpl.com/storm/hurricane_history.shtml)

CDC, (2005, July 20). Carbon monoxide poisoning from hurricane - associated use of portable generators. Retrieved January 22, 2008, from CDC Web site: Generators carbon monoxide poisoning from hurricane and associated use of portable generators.....article from CDC.htm

City of Delray Beach Fire Department, Florida. (2006). *Delray beach fire department annaul report fy 2005-2006* Delray Beach:

Consumer Reports, (2006, January). Portable generators: power in an emergency.

Retrieved January 22, 2008, from Consumer Reports Web site:

<http://www.consumerreports.org/cro/home-garden/home-improvement/home-security/generators/portable-generators-power-in-an-emergency-106/overview/index.htm>

CPSC, (2006, August 21). CPSC approves NPR proposing new warning labels for portable generators. Retrieved January 25, 2008, from CPSC Web site:

<http://www.cpsc.gov/cpscpub/prerel/prhtml06/06239.html>

CPSC, (2006, October 26). Comission briefing on portable generators. Retrieved January 22, 2008, from CPSC Web site: [www.cpsc.gov/volstd/engine/portgenstaffrev.pdf](http://www.cpsc.gov/volstd/engine/portgenstaffrev.pdf)

CPSC, (2007, January 4). New danger label required on all portable generators. Retrieved January 25, 2008, from CPSC Web site:

[www.ihs.gov/MedicalPrograms/PortlandInjury/PDFs/CPSC-NewGeneratorWarningLabels-PressRelease.pdf](http://www.ihs.gov/MedicalPrograms/PortlandInjury/PDFs/CPSC-NewGeneratorWarningLabels-PressRelease.pdf)

- CPSC, (2007, October 23). Voluntary standarda portable generators. Retrieved January 24, 2008, from CPSC Web site: <http://www.cpsc.gov/volstd/engine/engine.html>
- Delphi, (2006, October 12). Engine management systems. Retrieved January 28, 2008, from Delphi Automotive Web site:  
<http://delphi.com/manufacturers/auto/powertrain/gas/ems/small/>
- Delray Beach, (2000). Greater delray beach chamber of commerce. Retrieved January 22, 2008, from Delray Beach Demographics 2000 census Web site:  
<http://www.delraybeach.com/movebiz.asp>
- FDOH, (2005, September 20). Hurricane information sheet. Retrieved January 25, 2008, from Floridadisaster.org Web site:  
[www.floridadisaster.org/eoc/eoc\\_activations/Katrina05/Reports/final\\_CO-dangers%20MRF%209.20.05.pdf](http://www.floridadisaster.org/eoc/eoc_activations/Katrina05/Reports/final_CO-dangers%20MRF%209.20.05.pdf)
- FEMA, (2004, September 28). Portable generator warning. Retrieved January 25, 2008, from fema.gov Web site: <http://www.fema.gov/news/newsrelease.fema?id=14329>
- Fireboy, Carbon monoxide detectors. Retrieved January 28, 2008, from Fireboy Xintex Web site: <http://www.fireboy-xintex.com/co-detectors.html>
- FLDEM, (2007, June 1). Annual hurricanre preparedness sales tax holiday. Retrieved January 25, 2008, from floridadisaster.org Web site:  
[www.floridadisaster.org/eoc/eoc\\_Activations/Press06/Reports/TAXHOLIDAY2007MA.pdf](http://www.floridadisaster.org/eoc/eoc_Activations/Press06/Reports/TAXHOLIDAY2007MA.pdf) -
- FLynn, J. (Ed.). (2007). Non Fire Carbon Monoxide Incident Reported 2007. Quincy, Ma: NFPA.

- Frey, H (2003). On road measurement of vehicle tailpipe emission using a portable instrument. *Journal of the Air and Waste Management Association*. 53,
- Lawn and Landscape, (2006, November 21). Ethanol grounds small lawn care equipment. Retrieved January 28, 2008, from Lawn and Landscape.com Web site:  
<http://www.lawnandlandscape.com/news/news.asp?ID=4902>
- NFPA, (2007, August). Portable generators. Retrieved January 22, 2008, from NFPA Web site:  
<http://www.nfpa.org/itemDetail.asp?categoryID=1383&itemID=32125&URL=Research%20&%20Reports/Fact%20sheets/Safety%20in%20the%20home/Portable%20generators&cookie%5Ftest=1>
- Nice, K How catalytic converters work. Retrieved January 28, 2008, from How stuff works Web site: <http://auto.howstuffworks.com/catalytic-converter.htm>
- Propane Council, (2006, September). Propane meets new epa standards. Retrieved January 28, 2008, from Propanecouncil.com Web site:  
[www.propanecouncil.org/files/Capital\\_Awareness\\_Program\\_s\\_PropanE-NEWS\\_-\\_September\\_2006.pdf](http://www.propanecouncil.org/files/Capital_Awareness_Program_s_PropanE-NEWS_-_September_2006.pdf)
- RFA, Ethanol facts environment. Retrieved January 28, 2008, from Renewable Fuels Association Web site: <http://www.ethanolrfa.org/resource/facts/environment>
- Technology, (2003, October 31). Commercialization of the three way catalytic converter. Retrieved January 28, 2008, from Technology.gov Web site:  
[www.technology.gov/Medal/2002/bios/MooneyKeith.pdf](http://www.technology.gov/Medal/2002/bios/MooneyKeith.pdf)

USFA, (2007, February 7). Carbon monoxide. Retrieved January 25, 2008, from United States Fire Administration Web site:

[http://www.usfa.dhs.gov/citizens/all\\_citizens/co/index.shtm](http://www.usfa.dhs.gov/citizens/all_citizens/co/index.shtm)

Van Sickle, D (2007).Carbon monoxide poisoning in florida during the 2004 hurricane season. *American Journal of Preventative Medicine*. 34, 340.

Appendix A

**Generator Survey**

**1) Are you aware of any carbon monoxide poisonings or deaths due to the use of a portable generator after a hurricane within your jurisdiction?**

- a. Yes
- b. No

**2) Are you aware of any carbon monoxide poisonings or deaths due to the use of a portable generator after a hurricane within Palm Beach County?**

- a. Yes
- b. No

**3) What was done by your agency to address the problem of carbon monoxide poisoning from portable generators?**

- a. Public service announcements (TV, Radio, Print, Other)
- b. Increased patrols
- c. Reverse 911 messaging
- d. Nothing



- 4) **Would your organization consider adding a carbon monoxide detector component to you existing smoke alarm program?**
- a. Yes
  - b. No
- 5) **Has your local jurisdiction enacted any rules to address the use of portable generators?**
- a. Yes
  - b. No
- 6) **Does your jurisdiction require carbon monoxide detectors in new construction?**
- a. Yes
  - b. No
- 7) **Would you support requiring generator manufacturers to add equipment to make them safer in respect to carbon monoxide poisonings?**
- a. Yes
  - b. No

8) **Which of the following is the most important improvement a generator manufacturer should implement to lower incidents of carbon monoxide poisonings and deaths?**

- a. Reduce carbon monoxide emissions
- b. Improve signage and warnings
- c. Detection equipment that shuts the unit down when elevated carbon monoxide levels are detected

## Appendix B

## Generator Survey Results

1) **Are you aware of any carbon monoxide poisonings or deaths due to the use of a portable generator after a hurricane within your jurisdiction?**

- |    |     |    |
|----|-----|----|
| a. | Yes | 12 |
| b. | No  | 9  |

2) **Are you aware of any carbon monoxide poisonings or deaths due to the use of a portable generator after a hurricane within Palm Beach County?**

- |    |     |    |
|----|-----|----|
| a. | Yes | 19 |
| b. | No  | 2  |

3) **What was done by your agency to address the problem of carbon monoxide poisoning from portable generators (circle all that apply)?**

- |    |  |    |
|----|--|----|
| a. | Public service announcements (TV, Radio, Print, Other) | 5  |
| b. | Increased patrols                                      | 1  |
| c. | Reverse 911 messaging                                  | 2  |
| d. | Nothing  | 14 |

- 4) **Would your organization consider adding a carbon monoxide detector component to you existing smoke alarm program?**
  - a. Yes 20
  - b. No 1
  
- 5) **Has your local jurisdiction enacted any rules to address the use of portable generators?**
  - a. Yes 3
  - b. No 18
  
- 6) **Does your jurisdiction require carbon monoxide detectors in new construction?**
  - a. Yes 1
  - b. No 20
  
- 7) **Would you support requiring generator manufacturers to add equipment to make them safer in respect to carbon monoxide poisonings?**
  - a. Yes 20
  - b. No 1

8) Which of the following is the most important improvement a generator manufacturer should implement to lower incidents of carbon monoxide poisonings and deaths?

- |    |  |    |
|----|--|----|
| a. | Reduce carbon monoxide emissions   | 4  |
| b. | Improve signage and warnings   | 1  |
| c. | Detection equipment that shuts the unit down when elevated carbon monoxide levels are detected | 16 |

## Appendix C

### Sec. 95.16. PORTABLE GENERATORS.

(A) The use and operation of a portable auxiliary electrical generator is prohibited within or on the following areas:

- (1) Within five (5) feet of any opening (includes, but is not limited to, doors and windows) into a building or structure;
- (2) Within garages, enclosed or partially enclosed areas, or under eaves or other overhangs;
- (3) On roofs or roof areas, balconies, ingress/egress areas and discharge ways, including but not limited to walkways, stairways and stairwells.

(B) The generator shall be operated in a safe manner and in accordance with NFPA 70, the National Electric Code and all other applicable laws, regulations and City ordinances.